

Exploring the Thermal Limits of IR-Based Automatic Whale Detection (ETAW)

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LONG-TERM GOALS

Growing concerns, that aquatic noise produced during naval exercises and offshore seismic surveys may be harmful to marine mammals, have led an increasing number of regulating agencies to request mitigation measures when issuing permits for such surveys in their nations' EEZ. The most common measure is to implement a "marine mammal watch", a team of observers that scans the ship's environs for signs of presence of marine mammals to trigger a shutdown of the hydroacoustic source when marine mammals are entering a predefined *exclusion zone*.

Marine mammal observers usually scan the ship's environs for whales using binoculars or the naked eye. Sightings mostly rely on spotting a whale's blow, which might rise to a height of several meters but is visible for a few seconds only. Hence, in combination with the whales' prolonged dives, sighting opportunities are rare, which, in addition to the limited field of view and finite attention span of human observers, renders this method personnel-intensive and difficult, even during fair weather and daytime. During darkness it is not feasible.

Our long-term goal is to overcome these difficulties and to develop a reliable, automatic whale detection system for the full range of oceanic environmental conditions (wind, sea surface temperature) and species. To this end, we developed a ship-based thermal imaging system for automated marine mammal detection, consisting of an actively stabilized, spinning IR camera and an algorithm that detects whale blows on the basis of their thermal signature. So far, this technology has been tailored to and tested under cold ($SST < 10^{\circ}C$) water conditions only, as this is where the technology was expected to perform best. To adapt the technology to warmer environments and to test its performance there is the specific goal of this proposal.

OBJECTIVES

This proposal aims at a cost-efficient test of the thermal limits of the abovementioned IR based automatic whale detection technology by attempting to capture whale spouts during the northward humpback whale migration, which occurs annually rather close to shore near North Stradbroke Island, Queensland, Australia. Based on the collected data, detector/classifier optimization shall be performed

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and ensuing system performance be tested by subsequent comparisons with concurrent visual observations.

APPROACH

By obtaining continuous IR video footage during two successive northward humpback whale migrations and collecting concurrent independent (double blind) visual observations (modified cue counting), a data base will be created to:

- Determine the performance of the imaging device in warm waters;
- Determine the performance of the existing automatic detector in warm waters;
- Develop optimized auto-detection algorithms for the warm water realm;
- Determine the performance of the optimized detector in warm waters;
- Generate additional baseline data on locomotive behavior of migrating humpbacks (providing the proposed technology proves technically feasible); and
- Generate, for the first time, data on night time humpback migration; (providing the proposed technology proves technically feasible).

At AWI, key individuals for this project will be Daniel Zitterbart, overlooking the system development, and Elke Burkhardt, overlooking the concurrent sighting data acquisition. The field activities will be supported by Mike Noad, University of Queensland, who has organized many whale surveys off North Stradbroke Island.

WORK COMPLETED

With funding of this project having commenced in July 2013, only organizational activities occurred so far. However, in anticipation of the funding of this project, we undertook some key activities as early as fall 2012, to ensure this project can be implemented as planned should it be funded. These include:

- A visit to the field site, North Stradbroke Island, Queensland, Australia, in fall 2012 to select the most suitable location for the installation of the IR camera allowing operations day and night.
- Personal meeting with Mike Noad to discuss details of the project's field-work.
- Securing of access to the chosen field site for the first field season (signing of rental agreement for suitable ocean view house covering the period 08 June 2014 – 20 July 2014).
- Market research regarding configuration of workstation for data acquisition and software development.
- Hiring of key personnel.
- Initiation of the application process for the necessary research permits.

RESULTS

Prior work, as recently published in Zitterbart et al., shows that for the cold water realm, the system detected 92% of all visually logged ship-whale encounters during Polarstern expedition ANT-28.2 and 82% of cues recorded by a team of visual observers during ANT-27.2. During these expeditions, the system detected about twice (2.5- and 2.1-fold) as many encounters and cues, respectively, as recorded by the MMOs, with false positive rates of less than 1 per 4 minutes occurring for the majority (>90%) of virtual 2-hour watches. The yet unresolved question, whether comparable results can be achieved in warm water regions, is the subject of this project.

IMPACT/APPLICATIONS

With regard to marine mammal mitigation applications, the real-time detection and tracking capability of thermal imaging methods allows for fast and correct decisions, day and night, throughout seismic surveys or naval activities. In particular, the IR system's ability to concurrently detect multiple whales allows for full situation awareness, even in the presence of many whales.

In addition, the system provides precise and reproducible distance and bearing information which may be used to study the response of whales to acoustic exposure with regard to locomotive behavior, respiration rates, and dive cycles. Automated blow detection can be coupled with acquisition of additional visual imagery for species identification and morphometric analyses, an approach currently under development. The increased use of such systems will eventually result in a large number of well documented encounters, providing urgently needed, statistically robust data resolved at the species and contextual levels.

TRANSITIONS

Rheinmetall Defence Electronics, Bremen, Germany, has acquired a license of the AWI-developed data acquisition software and current cold-water detection kernel and is marketing the entire system (the FIRST-NAVY sensor head and the AWI-built software components) under the acronym AIMMMS (Automatic Infrared Marine Mammal Mitigation System). However, with the current classification kernel being only applicable to cold water realms, marketing only occurs for polar and sub-polar regions. Any further software developments made during or sponsored by ONR through ETAW do not fall under the current licensing agreement.

RELATED PROJECTS

We are not conducting any related projects at this time, nor are we aware of any other project perusing this technology being conducted by our colleagues.

PUBLICATIONS

Note: The papers/reports listed hereinafter describe the current state of development with regard to "cool water" deployments and basically describes the *prior knowledge* that is being entered into the ETAW (i.e. this) project by AWI.

- Zitterbart DP, Kindermann L, Burkhardt E, Boebel O (2013) Automatic Round-the-Clock Detection of Whales for Mitigation from Underwater Noise Impacts. PLoS ONE 8(8): e71217. doi:10.1371/journal.pone.0071217 [published, refereed]
- Boebel O., Bombosch A., Burkhardt E., Cammereri A., Kindermann L., Richter S., Zitterbart DP. MAPS: Marine Mammal Perimeter Surveillance. In: Boebel O., editor. The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2012/2013 (ANT-XXIX/2). Bremerhaven: Reports on Polar and Marine Research. [in press]
- Burkhardt E., Lanfredi L., Richter S., Boebel O., Kindermann L., Zitterbart DP. MAPS: Marine Mammal Perimeter Surveillance. In: Lucassen M., editor. The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2012 (ANT-XXVIII/4). Bremerhaven: Reports on Polar and Marine Research. 652 , 89 p. 2012 .
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- Burkhardt E., Kindermann L., Zitterbart DP., Reimann A. MAPS: Marine Mammal Perimeter Surveillance In: Budeus G., editor. The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2010 (ARK-XXIV/1). Bremerhaven: Reports on Polar and Marine Research, 612, 31-34, 2010.

PATENTS

Note: The patent application below describes the current state of technology and basically describes the prior knowledge that is being entered into the ETAW (i.e. this) project by AWI.

Zitterbart DP, Kindermann L, Boebel O; Method for automatic real-time monitoring of marine mammals, US Patent Application 20,130,070,079, WO Patent Application 2,013,037,344.